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Research Paper

Mineral Potential Mapping Using Principal Coordinate Analysis and Principal Component Analysis in 1:100,000 Scale Porang Sheet, South Khorasan Province

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Abstract: The 1:100,000-scale Porang sheet in South Khorasan province is prone to skarn, massive sulfide, and sedimentary mineralization due to the presence of intermediate to ultrabasic volcanic and plutonic rocks and the variety of sedimentary rocks. This paper introduces the Principal Coordinate Analysis (PCoA) method. The PCoA method, along with the Principal Component Analysis (PCA) and Correspondence Analysis (CA) methods, has been used to identify the possible type of mineralization in the study area. Geological and mineralogical data and the analysis results of 25 elements from 314 stream sediment samples, taken from the study area, have been used for this purpose. The results of the data analysis show that the D1 coordinate, PC1 score, and location in the first cluster maps of the samples are most likely related to the mineralization in ultrabasic, basic, and listivinite rocks. After that, the D2 and D3 dimension maps, the PC2 and PC5 score maps, and the sample location map in the fifth cluster related to sedimentary rocks attribute the most probability to sedimentary mineralization, especially of Mn and Fe mineralization types, in the study area. Finally, there is the possibility of skarn and massive sulfide mineralization, whose locations can be predicted by the D4 dimension maps, the PC3 score map, and the sample location maps in second, third, and fourth clusters. Also, the comparison of data analysis results with two multivariate statistical methods shows that by choosing the number of dimensionality reductions, the principal components method can cover more variability than the principal dimensions method. While connecting the principal coordinate maps to the mineralization is easier and more reliable than the principal component score maps. Therefore, the proposal of this paper is the simultaneous use of PCoA and PCA methods to analyze geochemical data in an exploration region.

Keywords: Principal coordinate analysis, Principal component analysis, Mineral potential mapping, Multivariate statistics, Porang sheet.

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INTRODUCTION

The Principal Component Analysis (PCA) method is better known as a dimensionality reduction method. This method is used in the analysis of geochemical data to identify relationships between variables and group the samples to determine geochemical anomalies and mineral potential mapping [1-4]. At the same time, the Principal Coordinate Analysis (PCoA) method is also used as a powerful dimension reduction method to analyze a proximity matrix [5-7], which has received less attention from geoscience experts. Therefore, this paper introduces this method and will examine its application in mineral potential mapping. For this purpose, the geological and geochemical data of the 1:100,000 Porang sheet in South Khorasan province will be used to identify the type and potential of mineralization in this sheet. The principal component analysis and correspondence analysis, as well-known and conventional methods, will also be used to compare and check the accuracy of the obtained results.

METHODS

The PCoA method is one of the multi-dimensional scaling techniques that is used to reduce the dimension of a dataset for better display and analysis. In this method, a confusion matrix, such as a correlation or distance matrix, is first calculated. Then, the entries in this matrix are affected by the average of the samples, variables, and total data. Finally, the singular value decomposition technique is used to estimate the eigenvalues and eigenvectors of this matrix.

In this paper, the PCoA, PCA, and CA methods are used on the exploration data of the Porang sheet. These data include geological and mine data and the analysis results of 25 elements from 314 samples taken from stream sediments in the study area.

FINDINGS AND ARGUMENT

The obtained results of the PCoA and PCA methods show that the possibility of mineralization related to ultrabasic, basic, and listivinite rocks in the study area is highest because the D1 dimension maps and PC1 score maps are associated with this mineralization (Figures 1 and 2). After that, the D2 and D3 dimension maps and the PC2 and PC5 score maps related to sedimentary rocks attribute the most probability to sedimentary mineralization, especially Mn and Fe mineralization in the Porang sheet (Figures 1 and 2). Finally, there is the possibility of skarn and massive sulfide mineralization, whose locations can be predicted by the D4 dimension maps and the PC3 score map (Figures 1 and 2).

Figure 3 shows the location of the samples from each cluster on the geological map of the study area that was obtained by the CA method. According to the overlap of the location of the samples with the rock units and elements placed in each cluster, the highest probability of mineralization can be attributed to ultrabasic-basic rocks and listonites, samples of the first cluster, and then to sediment mineralizations of Mn and Fe elements, samples of the fifth cluster, in the study area. The location of samples of the second, third, and fourth clusters in sedimentary rocks can be associated with possible skarn mineralization.

CONCLUSIONS

In this paper, while introducing the Principal Coordinate Analysis (PCoA) method, the PCoA method was used along with the conventional PCA and CA methods to predict the probability of mineralization in the 1:100,000 Porang sheet. The results of these multivariate statistical methods show that the probability of mineralization related to ultrabasic, basic, and listivinites is higher in the study area.

The comparison of data analysis results with PCoA and PCA methods shows that by choosing the number of dimensionality reductions, the principal component method can cover more variability than the principal dimension method. In contrast, connecting the principal coordinate maps to the mineralization is easier and more reliable than the principal component score maps. Therefore, the proposal of this paper is the simultaneous use of PCoA and PCA methods to analyze geochemical data in an exploration region.

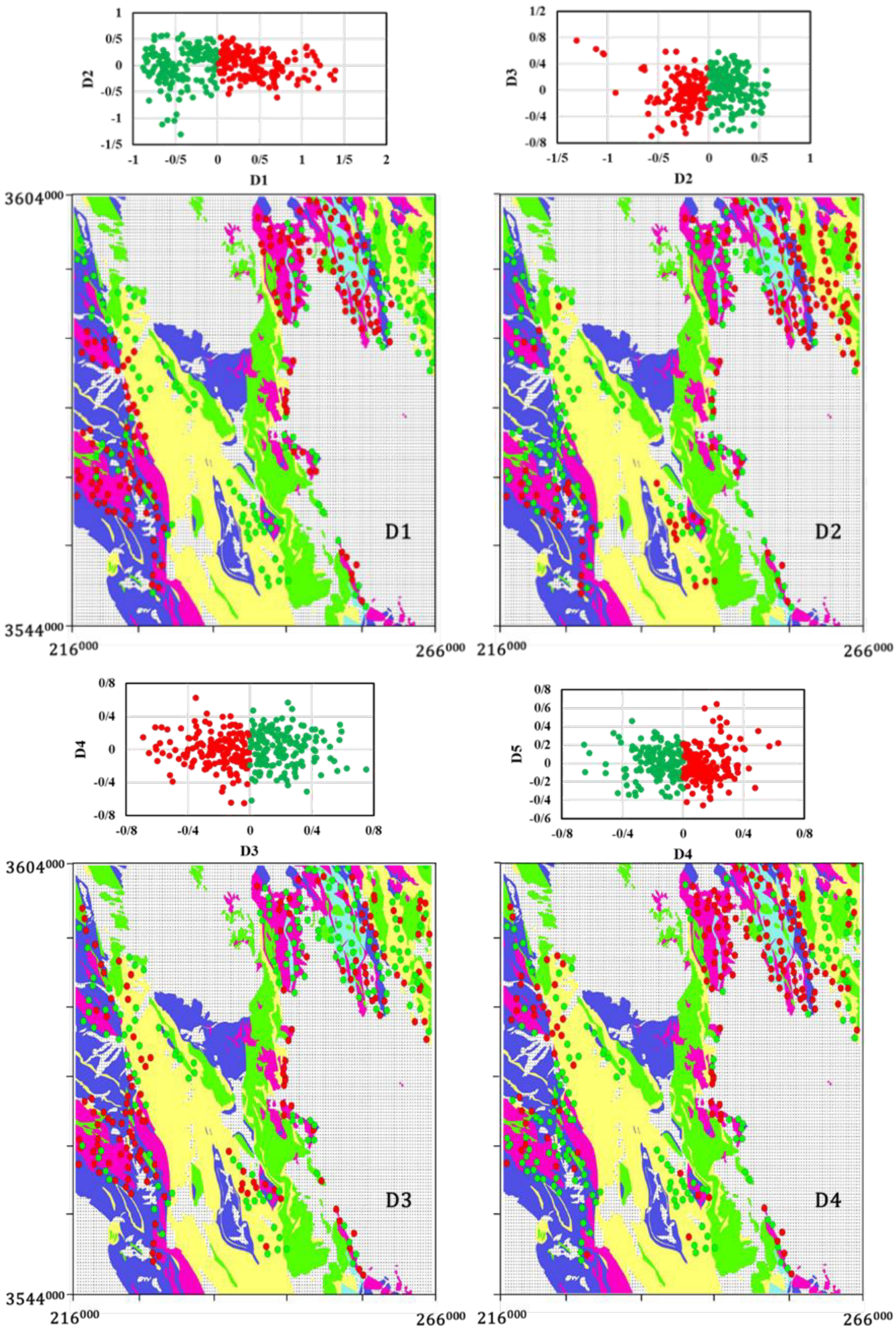

Figure 1. Coordinates of the samples in the principal dimensions obtained by the PCoA method along with their separated locations on the geological map of the Porang sheet

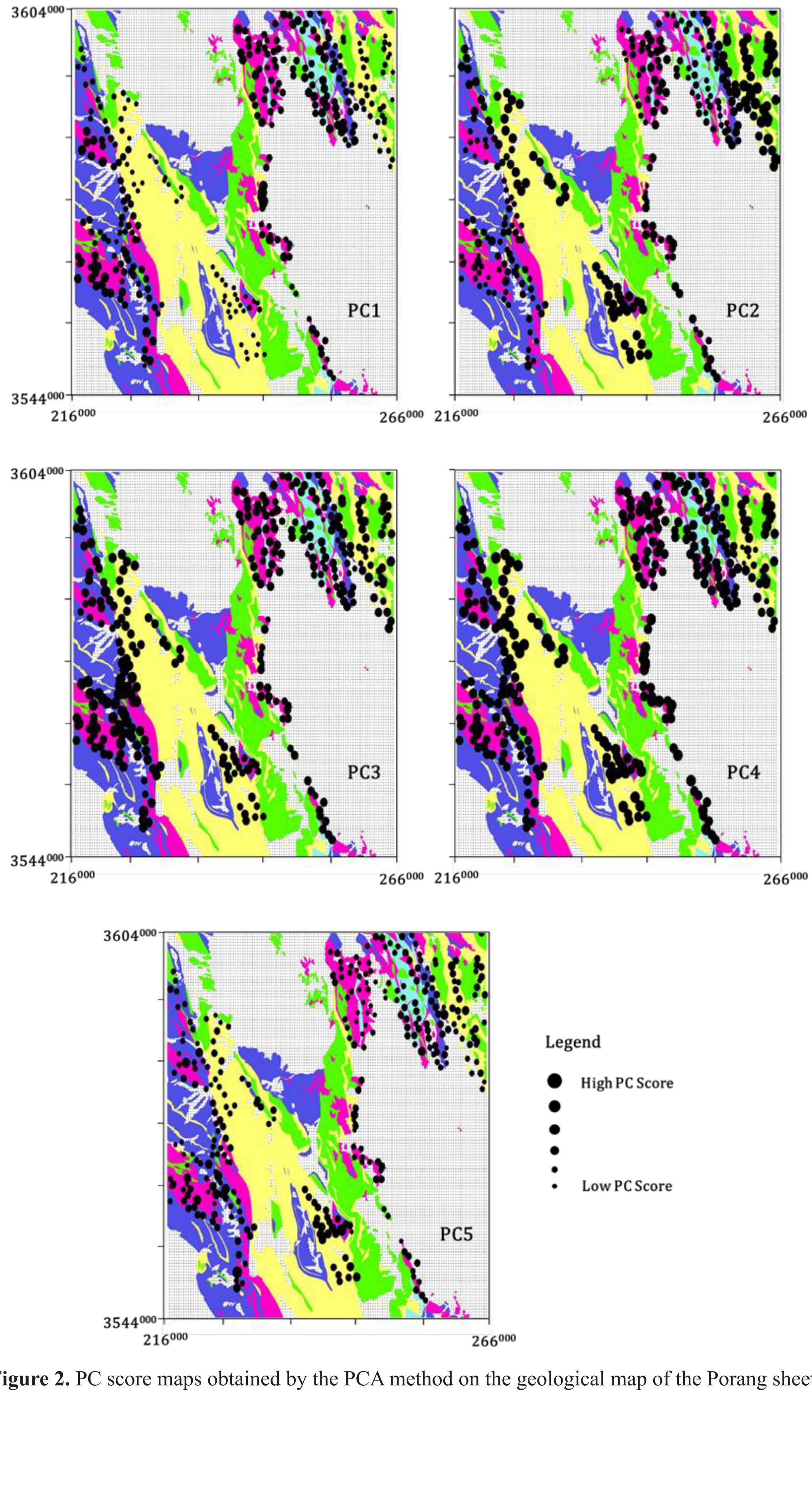

Figure 2. PC score maps obtained by the PCA method on the geological map of the Porang sheet

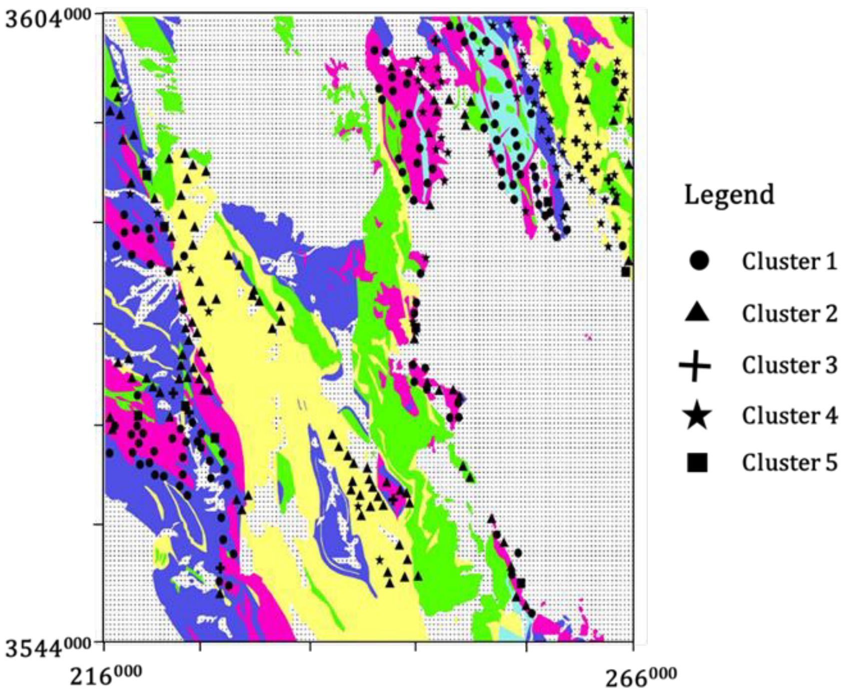

Figure 3. Location of the samples from each cluster obtained by the CA method on the geological map of the Porang sheet

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